

- 19 -  
**CLAIMS**

1. An apparatus including multiple ion guns and multiple associated ion optical columns for focused ion beam processing of materials or imaging, comprising:

one or more sealable ion gun chambers;

one or more ion guns positioned within each of the one or more ion gun chambers, each ion gun capable of generating an ion beam;

multiple ion optical columns, each ion optical column being associated with one of the multiple ion guns for focusing and directing the corresponding ion beam toward a target;

a primary vacuum chamber for containing a target for processing or imaging;

a vacuum valve associated with each of the ion guns, the vacuum valves selectively opening to allow the corresponding ion beam to pass from the associated ion gun to the target or selectively closing to seal the corresponding ion gun chamber.

2. The apparatus of claim 1 comprising a single sealable ion gun chamber having positioned therein multiple ion guns.

3. The apparatus of claim 1 comprising multiple sealable ion gun chambers each including one or more ion guns.

4. The apparatus of claims 1 in which each sealable gun chamber includes a vacuum pump.

5. The apparatus of claim 1 in which the vacuum valves associated with the ion guns in each of the one or more gun chambers are connected so that the vacuum valves in each gun chamber open and close using a single control.

6. The apparatus of claim 1 in which each of the ion optical columns includes a deceleration lens element maintained near ground potential.

- 20 -

7. The apparatus of claim 1, in which each of the ion optical columns includes optical elements and in which corresponding ones of at least one of the optical elements in different ones of the ion optical columns within a single gun chamber comprise an optical element bar to provide a common voltage to corresponding optical elements within the gun chamber.

8. The apparatus of claim 7, in which electrically isolated lens elements are placed in the optical element bar to allow independent control of some of the optical elements comprising the optical element bar.

9. The apparatus of claim 1, in which the ion optical column includes multiple lens elements and further comprising means for collecting secondary particles through at least one of the lens elements for imaging or characterizing the target surface.

10. The apparatus of claim 9, in which the ion optical column further includes a deflector for deflecting secondary particles out of the path of the ion beam and in which the ion optical column includes at least one lens element between the deflector and the target, the lens element biased to a voltage of a polarity opposite to that of the charge or the secondary particles to accelerate the charged secondary particles up through and past the lens element for detection.

11. The apparatus of claim 9, in which the sample is biased to the same polarity as that of the charge on the secondary charged particles to accelerate the charged particles up through and past the lens and electrostatic deflector for detection.

12. The apparatus of claim 9, further comprising for detecting the charged secondary particles where the detector of charged particles is a channel plate multiplier or scintillator detector placed substantially perpendicular to the primary beam with a center hole for the primary beam to pass through.

- 21 -

13. The apparatus of claim 9 further comprising a magnetic deflector, a Wein filter or an electrostatic deflection device for deflecting the secondary particles away from the ion beam path for collection.

14. The apparatus in claim 9, further comprising a mass spectrometer for Secondary Ion Mass Spectrometry for detecting and characterizing the secondary charged particles.

15. The apparatus of claim 1 in which at least some of the ion guns and ion optical columns are tilted at an angle of about three degrees to a normal to the sample surface.

16. The apparatus of claim 15 in which the ion guns in a first one of the multiple ion beam gun chamber are tilted at an angle of about three degrees in a first direction from a normal to the sample surface and in which the ion guns in a second one of the multiple ion beam gun chamber are tilted at an angle of about three degrees from a normal to the sample surface in a direction opposite to the first direction.

17. The apparatus of claim 1 in which each of the ion optical columns includes beam offset, scanning, steering and stigmation controls and in which the beam offset, scanning, steering and stigmation can be controlled independently for each column.

18. The apparatus of claim 1 further comprising a high voltage supply for providing a high voltage to corresponding optical elements in multiple ones of the ion optical columns.

19. The apparatus of claim 18 further comprising means for adjusting the voltage in one of the ion optical columns to deviate from the high voltage provided by the high voltage power supply.

20. A multiple column focused ion beam system:

multiple ion beam sources for forming multiple ion beams;

- 22 -

a bar having holes for forming therein multiple ion optical lenses, each ion optical lens corresponding to one of the multiple ion beam sources, each ion beam source and ion optical lens forming part of an ion beam optical column; and

a power supply for applying a voltage to lenses corresponding to the bar, thereby applying a common voltage to ion optical lenses in different optical columns.

21. The apparatus of claim 20 in which the bar comprises a flat conductive bar and in which the power supply provides a voltage directly to the conductive bar, the holes in the conductive bar functioning as ion optical lenses.

22. The apparatus of claim 20 in which the bar comprises a flat conductive bar having electrically isolated lenses formed therein and in which the power supply provides a common voltage to all lenses in the bar and selectively provides a second voltage to individual lenses in the bar.

23. The apparatus of claim 20 in which the bar comprises a flat non-conductive bar having electrically isolated lenses formed therein and in which the power supply provides a common voltage to all lenses in the bar and selectively provides second voltages to individual lenses in the bar.

24. The apparatus of claim 20 further comprising means for collecting through the lenses secondary particles emitted from the target, the secondary particles being used to image or to characterize the target surface.

25. The apparatus in claim 23 in which individual emitters are restarted by biasing either the extractor with respect to the emitter/ suppressor elements about -2000 V, or by biasing the emitter/ suppressor elements with respect to the extractor element about 2000 V, in the individual guns as needed.